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A STUDY OF SOME PHYSIOLOGIC RESPONSES OF CHILDREN TO THEIR INITIAL DENTAL EXPERIENCE

by

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ABSTRACT

Four different physiologic responses of children to their initial dental experience were studied. Heart rate was monitored by ECG electrodes placed on the left wrist and right leg. The muscle activity of the vastus medialis muscle was recorded by two surface electrodes on the left leg. Skin potential changes were recorded from electrodes placed on the tip of the thumb and tip of the little finger of the right hand. Respiratory pattern was recorded by means of a corrugated rubber tube placed around the chest. The patients were used as their own controls by measuring responses in a non-dental environment and then, without removing the electrodes, moving the patients into a dental operatory where responses to various simple dental procedures were recorded.

The findings in the study led to the following conclusions:

1) The dental environment is capable of eliciting physiologic responses commonly associated with stress. Muscle activity and skin potential activity showed a pronounced increase throughout the exposure of the subjects to the dental environment. Heart rate showed an initial increase followed by a sharp decrease during the intra-oral examination. Although changes in respiration were recorded, the variability of the response pattern prevented a meaningful analysis of the effect of the dental environment on respiration.

2) Certain aspects of the dental environment such as the dental chair, dental lamp, and white uniforms appear to be as stressful as actual treatment procedures.

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STATEMENT OF THE PROBLEM

The research project arose out of the concern of dentists for the anxiety of child dental patients, and was designed to investigate the degree of anxiety which might be provoked in new patients by certain routine, painless procedures commonly encountered at the first dental appointment. Difficulties were anticipated at the conceptual, practical and interpretive levels. At the conceptual level, we must accept a basic premise that the dental environment is a possible source of stress. It then becomes necessary to arrive at a concept of stress. On the practical level, the investigator is faced with a two-fold problem; the human variable must be considered and controlled to reasonable or acceptable limits; and the "experiment" must realistically approach a "real life" situation. It was imperative that the subjects be without previous dental experience or pre-conditioning and that the experimental situation closely parallel a normal first visit to the dentist. On an interpretive level, the investigator is faced with the relatively undefined task of attributing psychological causes to physiological effects.

Although studies of human behavior in stressful situations do not lend themselves well to the ideal experimental investigation as legitimately as exact sciences, they do provide additional valuable information in an important field.

In summary, the problem involved a study of the effect of the initial dental experience on the heart rate, muscle activity, skin potential and respiration of eleven children.

PART I

BACKGROUND

Dental research has made great strides in the past few decades, resulting in vastly improved equipment, materials, techniques and understanding of the oral tissues in both healthy and diseased states. In this search for knowledge and understanding, the emphasis, even in clinical investigations, has been placed on basic problems. Dentists have tended to look at their patients in relation to the technical problems arising from their treatment needs. Most research which has been directed to the improvement of the patient's acceptance of dental treatment has placed the emphasis on controlling and alleviating symptoms rather than understanding and correcting causes. Before a patient's attitude toward the dental experience can be effectively improved, the effects of the dental environment on that individual must be understood.

In considering the dental environment as a possible source of stress, a concept of stress itself must be developed. In the absence of a precise definition of stress, this investigator accepts the proposal of Lazarus[1] that stress be considered as a generic term describing a field of study. Stress, therefore, encompasses the stimuli which elicit reactions, the reactions themselves, and the various intervening processess. Appley and Trumbull[2], in a joint presentation to the Conference on Psychological Stress, made the following general observations on the concept of stress:

> 1. Stress is probably best conceived as a state of the total organism under extenuating circumstances rather than as an event in the environment.
> 2. A great variety of different environmental conditions is capable of producing a stress state.
> 3. Different individuals respond to the same conditions in different ways. Some enter rapidly into a stress state, others show increased alertness and apparently improved performance, whereas some appear to be "immune" to the stress-producing qualities of the

> environmental conditions.
>
> 4. The same individual may enter into a stress state in response to one presumably stressful condition, yet may not respond similarly to another apparently stressful situation.
> 5. Consistent intra-individual but varied inter-individual psychobiological response patterns occur in stress situations. The notion of a common stress reaction needs to be reassessed.
> 6. The behavior resulting from operations intended to induce stress may be the same or different, depending on the context of the situation of its induction.
> 7. The intensity and the extent of the stress state, and the associated behavior, may not be readily predicted from a knowledge of the stimulus conditions alone, but may require an analysis of underlying motivational patterns and of the context in which the stressor is applied.
> 8. Temporal factors may determine the significance of a given stressor and thereby the intensity and extent of the stress state and the optimum measurement of effect.

The remarks of Appley and Trumbull[2] suggest that stress is a response state and that its induction depends on the mediation of some appraising, perceiving, or interpreting mechanism.

Haggard[3] states:

> An individual experiences emotional stress when his overall adjustment is threatened and his adaptive mechanisms are severely taxed and tend to collapse. Some of the factors which influence an individual's ability to tolerate and master stress include:
>
> 1. The nature of his early identifications and his present character structure, and their relation to the demands and gratifications of the present stress-producing situation.
> 2. The nature of his reactions to the situation.
> 3. His ability to master strong and disturbing emotional tensions.
> 4. The extent to which he knows about all aspects of the situations, so that he is not helplessly unaware of the nature and source of threat.
> 5. His available skills and other means of dealing effectively with the threat, and the strength and pattern of his motivations to do so.

In discussing the processes that intervene between the stress stimulus and the individual's response, Lazarus[1] states:

> The mechanism by which the interplay between the properties of the individual and those of the situation can be understood is the cognitive process of appraisal, a judgment about the meaning or future significance of a situation based not merely on the stimulus, but on the psychological makeup.

> For threat to occur, an evaluation must be made of the situation, to the effect that a harm is signified. The individual's knowledge and beliefs contribute to this. The appraisal of threat is not a simple perception of the elements of the situation, but a judgment, an inference in which the data are assimilated to a constellation of ideas and expectation.

It is constantly emphasized in the literature that the objective reality of any given situation is not paramount in stress reaction studies, but that the personal factor and the series of subtle, subjective equations comprising the individual's own assessment of the stimulus are more important.

In discussing the psychological processes that intervene between the stress stimulus and response, Lazarus[1] states:

> "Threat" seems ideally suited to express the condition of the person or animal when confronted with a stimulus that he appraises as endangering important values or goals. When threat occurs, usually some behavior or psychological process is activated for the purpose of mitigating or eliminating the threat. This activity is called coping, and it is based on cognitive activity involving appraisal of the conditions of threat and the consequences of the coping behavior.

H. G. Wolff[4] states:

> The stress occurring from a situation is based in large part on the way the affected subject perceives it--perception depends upon a multitude of factors including the generic equipment, basic individual needs and longings, earlier conditioning influences, and a host of life experiences and cultural pressures.
>
> As a broad concept, stress may be viewed as a psychological and physiological phenomenon.

The term psychological stress is described by Appley and Trumbull[2] as embracing three specific areas.

On the stimulus side, the term psychological stress has been used to describe situations characterized as new, intense, rapidly changing, sudden or unexpected, including (but not requiring) approach to the upper thresholds of tolerability. At the same time, stimulus deficit, absence of expected stimulation, highly persistent stimulation, fatigue-producing and boredom-producing settings, among others, have also been described as

stressful, as have stimuli leading to cognitive misperception, stimuli susceptible to hallucination, and stimuli calling for conflicting responses.

On the response side, the presence of emotional activity has been used, post facto, to define the existence of stress. This usually refers to any bodily response which exceeds what is considered normal or usual (states of anxiety, tension, and upset). Any behavior which deviates momentarily, or over a period of time, from the normative value for the individual in question, or for an appropriate reference group, would be considered to arise from stress. The indices used to detect stress would include such overt emotional responses as tremors, stuttering, exaggerated speech characteristics, loss of sphincter control, or performance shifts such as perseverative behaviors, increased reaction time, erratic performance rates, malcoordination, error increase, and fatigue.

The existence of a stress state within the organism has also been inferred from one or more of a number of partially correlated indices, such as:

1. Reduction in circulating blood eosinophils.
2. An increase in 17 ketosteroids in the urine.
3. An increase in ACTH content or gluco-corticoid concentration in the blood.
4. Many physiological variables such as heart rate, galvanic skin response, and inspiration: expiration ratio have also been used to measure or explain stress.

Lazarus[5] distinguished between psychological stress and physiological stress as follows:

> The first main principle is that psychological stress, or threat, is mainly, if not entirely, a matter of anticipation. For a state of psychological stress to occur, the individual must recognize cues

> that herald future harm. Psychological stress involves an interpretation or appraisal that harm is to be expected. It is this anticipation that mediates the stress reaction, activating physiological, behavioral and psychological disturbances that are recognized as signs of stress.

Shannon and his colleagues[6] have compiled excellent evidence of the role which anticipation plays in dental stress situations. Shannon and Isbel[6] showed in 1963 that physical pain, tissue damage, and use of anaesthetic drugs did not produce measurable physiological stress reactions beyond those produced by the mere anticipation of such conditions. Two hundred and fifty eight healthy young males were subjected to an unexpected injection procedure. The following five experimental treatments were employed:

1. Injections of two percent Lidocaine HCl (hydrocholoric acid).
2. Injections of Lidocaine HCl with epinephrine, 1:100,000.
3. Injections of .9 percent sodium chloride.
4. Actual needle insertion with nothing injected.
5. A statement that injection would occur, with the injection needle being placed in the mouth but never touching the tissues.

All the experimental conditions produced significant increases in hydrocortisone in the blood, but no differences were found in the reactions to the different treatments.

In drawing conclusions from these findings, Shannon and Isbel[6] write:

> The findings of the present study indicate that the actual pain of needle injection is not a primary factor, that the onset of the symptoms of anaesthesia is not responsible, pharmacologic responses to the injected agents are negligible. Rather, the cortical stimulation seemed to result from the frank realization by the patient that he was to receive the injection and from the distress associated therewith.

In defining physiological stress, Lazarus[1] states:

> Physiological stress has to do with the visceral and neurohumoral reaction of man or animal to noxious stimulus agents that act directly on the tissues and the physiological mechanisms that account for it. The definition of noxious at the physiological level is relatively straightforward, especially if the characteristics of the physiological system are known. Noxious means any condition which is disturbing or injurious to tissue structure or function.

Our appraisal of children undergoing a dental experience leads us to consider an ontogenetic variation in stress response. Lazarus[1] states:

> Physiological structure is by no means the same in the infant, young child, and mature adult, and we should expect that important details of psychological stress production and reduction will be different at these developmental levels.

As motives and behavior patterns develop we can expect a change in the way an individual responds to a situation which has been appraised as a threatening one. As patterns of motivation develop, we can also expect a difference in situational appraisal.

Caudill[7] states:

> A child under stress is in a situation somewhat different both physiologically and socially from that of an adult under stress. The same sort of stressful event may have more drastic psychological and physiological consequences for a child; he is in a dependent position, he has fewer social roles and differentiated behavior patterns to help him meet a problem, and his life is not so sharply divided into as many areas (occupation, recreation, religion, family, and kinship) as that of an adult.

Since the children involved in this study were being exposed to the dental environment for the first time, we also had to consider the additional impact of "Novelty stress". Novelty in stress research is considered a consistently effective stressor. Mason[8] and Fishman et al[9], reported adrenocortical changes indicative of a stress response in individuals exposed to novel environmental situations. The stress response seen in novelty situations is thought to be due to fear of the unknown and the lack of an optimum level of patterned sensory input. The source of stress

in novel situations lies in the individual's appraisal of the threat involved.

Lazarus[1] states:

> .... observable threat and stress reactions are reflections or consequences of coping processes intended to reduce threat. The pattern of autonomic nervous system activity, as revealed by end organ reactions such as heart rate, skin conductance, respiration, etc., is determined by the nature of the coping process.
>
> In novel situations, an individual is confronted with a certain degree of stimulus ambiguity. This ambiguity of the stimulus cues has a double effect in psychological stress. The individual does not know the exact nature of the confrontation, nor does he know what can be done to cope with it if it is harmful.
>
> .... ambiguity concerning the significance of a stimulus configuration will usually intensify threat because it limits the individual's sense of control or increases his sense of helplessness over the danger. But this occurs only when there are other grounds, either situational or characterological, for being threatened.

Physiological Indicators of Stress

(a) Muscle Tension and Stress.

The concept of increased muscle activity associated with increased psychological tension has been well documented in the literature.

Malmo and Shagass[10] investigated the effect of painful heat stimulation of the skin upon electrical activity of the muscles of the neck. The changes in neck muscle activity were measured by means of electromyograph electrodes placed on the neck. It was found that muscle activity increased in anticipation of painful stimulation as well as during the actual painful stimulation. Perry, Lammie, Main and Teuscher[11] found a similar increase in electrical activity of masticatory muscles. Eight dental students who had agreed to participate in a study involving electromyographic recordings of the temporal and masseter muscles were suddenly confronted by the Dean of the Dental School. The Dean questioned each student regarding his prospects on impending examinations. Increased

activity was noted for both temporal and masseter muscles during the meeting with the Dean.

Benson and Gedye[12] proposed the use of the term "Irrelevant muscle activity" to describe the non-functional and non-specific increase in muscle activity associated with increasing psychological tension. In their experiments, they used electromyographic recordings of arm and leg muscles which were not involved in the performance of the tests. Electrical activity of these muscles increased as the performance requirements became more difficult. Horwitz et al[13] showed a correlation between psychological rigidity and muscle tension. Yemm[14,15,16] studied the electrical activity of masseter muscles during experimental stress-producing situations. He found increased activity in association with increased psychological tension.

(b) Heart Rate and Stress.

Considerable controversy surrounds the interpretation of heart rate changes in experimental situations. An increased rate is commonly seen in anxiety states.[17] This finding is well documented.

The controversy over changes in heart rate revolves around the fact that deceleration is also seen as part of a response pattern in which other somatic processes show the sympathetic-like changes thought universally to characterize arousal. The complex reflexive and homeostatic mechanisms regulating cardiovascular function may be responsible in part for the observed changes in heart rate. The heart does not control the cardiovascular system, but is rather a slave to the demands of that system. The prime example of cardiac deceleration during extreme stress is seen in the common fainting attack or vasodepressor syncope.[18,19]

In this case, the deceleration is due to a massive parasympathetic discharge from the vasomotor centre.

The subject's perception of the experimental stimulus has also been proposed as a factor in the explanation for cardiac deceleration in experimental situations. Lacey[20] and Lacey et al[21] called this phenomenon "situational stereotypy" and suggest that the source of the response pattern lies with the nature of the subject's set and expectation of his intended response to the stimulus. The individual's set and expectation is a result of his primary appraisal of the stimulus. Grinker and Spiegel[22] state:

> This appraisal of the situation requires mental activity involving judgment, discrimination and choice of activity, based largely on past experience. There is growing evidence that the pattern of autonomic nervous system activity, as revealed by end-organ reactions, such as heart rate, is determined by the nature of the coping process.

Lacey[20] found that a response pattern characterized by cardiac deceleration was seen in situations in which the subject was required to pay attention to the environment (environment detection). Cardiac acceleration was seen in situations involving rejection of the environment. Problem solving, with the emphasis placed on internal cognitive processes, would exemplify "environment rejection." Paying attention to visual or auditory stimuli, calling for no extensive cognitive elaboration, would be an example of "environment detection."

Similar results have been reported by Darrow[23], Obrist[24], Kagan and Rosman[25], Kagan and Lewis[26], Lewis et al[27]. Cardiac deceleration has also been reported in novelty situations, in which the nature of the stress is unknown. Stern and Word[28] feel that the cardiac deceleration is seen during the orienting ("what is it") response and cardiac acce-

leration is seen as part of a defensive response.

Johnson and Campos[29] oppose Lacey's concept of environmental rejection on the basis of their findings, which showed that changes in heart rate were attributable solely to the verbalization requirement in Lacey's experiment.

When approaching the problem of interpretation of relationships between psychological responses and physiological cardiovascular changes, another interesting fact should be considered. There is a possibility that changes in cardiovascular function could initiate or augment a state of anxiety in any given situation.

(c) Respiration and Stress.

In spite of the obvious interpretive difficulties, measurements of respiration were made. Respiration is a complex indicator which is subject to voluntary control, although its reflex regulation occurs in the respiratory centre of the medulla. This centre responds to changes in blood chemistry, especially to carbon dioxide and oxygen level.[30] There are two problems associated with using respiration as an indicator of emotional changes, namely:

1. A multiplicity of variables such as rate, depth, pattern, inspiration/expiration ratio, etc.
2. Respiration is subject to interference by various other reflexes such as coughing, sneezing, sighing and yawning. Furthermore, gasping and breathholding would lead to a false impression if the rate of respiration were used as the only indicator of anxiety.

Despite these disadvantages, respiration has been used in several studies as an indicator of anxiety (Brower[31], Malmo and Skagass[10],

Ax[32], Shachter[33]). Increased respiratory rate was found to be associated with anxiety in each of the studies. SRP and Kominek[34] noted respiratory variability in children who were exposed to various aspects of the dental environment.

(d) Electrical Phenomena of the Skin and their Relationship to Stress.

One of the most popular measures of autonomic activity associated with effective and emotional states is the measurement of changes in the electrical activity of the skin. This phenomenon has been variously referred to as the psychogalvanic reflex, skin resistance, palmar conductance, electrodermal response, and skin potential. The basis for all these measures is sweating, for which the effector mechanism is the action of the sweat gland membranes, activated by the sympathetic nervous system[30].

The endosomatic (potential) method was chosen for this study because it is relatively free of influence from the changing resistance level. Changes in skin potential arise from currents in the skin and are a function of the polarization-capacity effect resulting from the secretion of sweat.[42]

In recent years attempts have been made to measure the autonomic responses of patients in the dental environment. Lewis and Law[35] measured galvanic skin response, face temperature, hand temperature and heart rate on eighteen children between five and one half and seven years of age. They attempted to compare the psychophysiological reactions during an oral prophylaxis, with the parent either present or absent. Of the four responses measured, only heart rate showed a significant change when the parent was excluded from the room. Although changes in the other three responses were recorded, they did not approach significance.

Okubo[36] used a psychogalvanometer to record the emotional stresses experienced by patients undergoing routine dental treatment. Okubo found that patients who were nervous or anxious about dental treatment showed greater changes in electric current before and during treatment than did patients who were calm.

SRP and Kominek[34] measured heart rate and respiratory rate during four different dental incidents as follows:

1. Fifteen children (average age 14 years) were seated and the dental light was switched on. The heart rate was found to increase by three to five beats per minute. Respiration accelerated by one or two breaths per minute in five cases and retarded by one or two breaths per minute in four cases.
2. The dentist approached the dental chair and turned on the dental handpiece for 15 seconds. Twenty-five children (average age 13 years) were subjected to this procedure. The heart rate increased an average of ten beats per minute in response to the approaching dentist. The sound of the dental engine resulted in increases of 16 to 22 beats per minute. The recordings of respiratory rate revealed acceleration of one to four breaths per minute in 14 cases. Respiration was retarded in three cases and 14 cases respiratory arrhythmias of varying intensity were recorded.
3. Twenty children (average age 11 years) were approached by the dentist, shown the syringe, and were given a mandibular block injection. The heart rate was increased by six beats per minute in response to the approaching dentist, 18 beats per minute when the syringe was shown, and 25 beats per minute during the mandibular block injection. An increase in respiratory rate was seen in five cases and respiratory

arrhythmias were recorded in 17 cases.

4. The reactions of 20 children to the approaching dentist and to the words, "Nurse, the forceps please" were recorded. The heart rate increased by seven beats per minute in response to the approaching dentist and by 19 beats per minute in response to the words, "Nurse, the forceps please."

Stricker and Howitt[37] compared the heart rates of 12 children judged to be clinically apprehensive with 12 children who did not exhibit signs of apprehension. The patients in the two groups were equivalent with respect to prior dental experience, experimental treatment procedure, age, intelligence and manifest anxiety score. The children had a median age of six years. The clinically anxious group had a mean cardiac rate of 107.4 beats per minute, while the group not exhibiting anxiety averaged 90.3 beats per minute. Their research showed a statistically significant correlation between heart rate and clinical appraisal of anxiety.

Corah and Pantera[38] studied changes in the skin resistance of 28 men during a video simulation of a dental procedure. The patients were divided into high and low dental anxiety groups on the basis of their answer to the question, "If you had to go to the dentist tomorrow, how would you feel about it?" Stress was assessed subjectively and through skin resistance recordings. The subjects were shown three video presentations:

a) A control, showing a boy building a boat.

b) A dental procedure as it appears to the patient in the dental chair.

c) A dental procedure as it would appear to an onlooker.

The only significant difference found from the control level of skin conductance was in the high anxiety dental group who had observed the "first

person" dental video tape.

Corah[39] also studied 48 students in a simulated video tape dental procedure. The procedure was divided into the following five major segments:

a) Administration of anaesthesia.

b) Cavity preparation with a high speed dental handpiece.

c) Cavity preparation with a low speed dental handpiece.

d) Cavity preparation with hand instruments.

e) Carving an amalgam restoration.

Skin conductance and heart rate were measured using video, audio, and audio and video combined. The sight and sound combination produced the greatest change in heart rate and skin conductance.

PART II

METHOD

Description of the Experimental Situation

The experiment was carried out in a room divided in half by a partition five feet high. (Fig. 1) On arrival, the child was ushered into the "non-dental" half of the room. The walls and cabinets of this half of the room were covered with pictures and drawings of animals. Toys and books were available for the child's amusement. The investigator, wearing shirt and tie, sat facing the mother and child, who sat side by side in two large chairs. The child sat upright in the large chair with his legs supported as they would be in a contoured dental chair. The partition prevented the child from seeing the other half of the room.

The other half of the room was a normal dental operatory containing a Den-Tal-Ez contour chair, X-ray unit and Ritter operating unit. The recording equipment was situated in the dental operatory. The entrance to the dental operatory was blocked by a mobile dental cabinet which could be rolled aside to enable movement of the child to the dental chair.

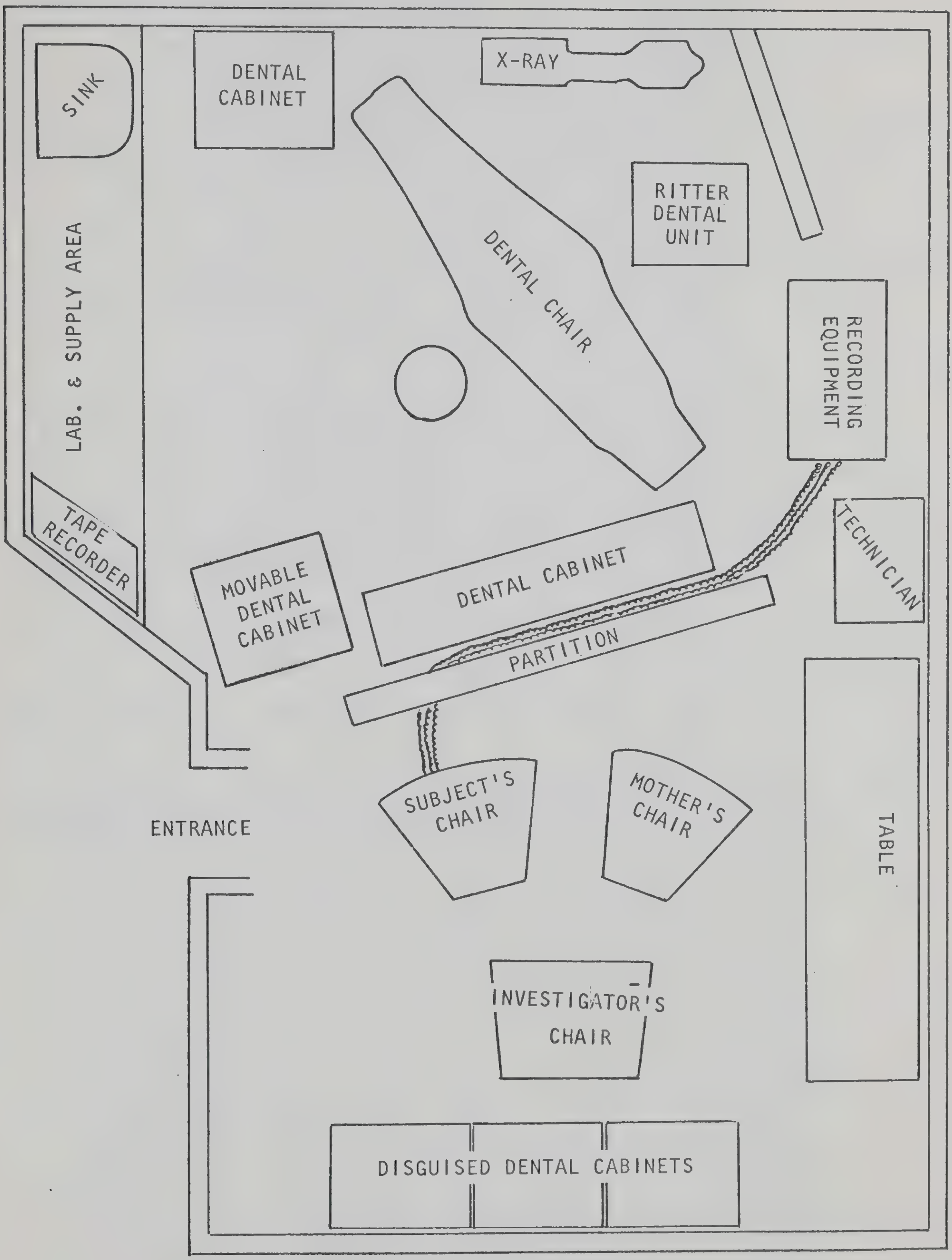

Fig. 1 - Schematic representation of the experimental area.

Description of Recording Equipment

The equipment used in this study consisted of a Harvard Modular Recording system, Beckman biopotential skin electrodes and a pressure transducer and converter for respiration. The modular system consists of a variable speed chart mover, recording modules, A.C./D.C., bioamplifiers and an event marker. (Figs. 2, 3, 4) The electrocardiograph and electromyograph electrodes were silver - silver chloride pellets encased in a 19 mm x 5 mm plastic case and coloured for easy identification. The skin potential electrodes were similar and were encased in a 10 mm x 5 mm plastic case. After an application of electrolytic gel, the electrodes were fastened to the skin with self-adhesive collars. (Fig. 5) After placement, the large electrodes usually have an electrode/skin impedance of 300 ohms. The smaller electrodes have an impedance of about 3000 ohms.

To record small chest movements, a piece of corrugated rubber tubing (Fig. 6) was stretched around the chest and connected to a low pressure Statham gauge. In order to adapt this apparatus to the Harvard equipment, a 6-volt battery-powered converter had to be designed.

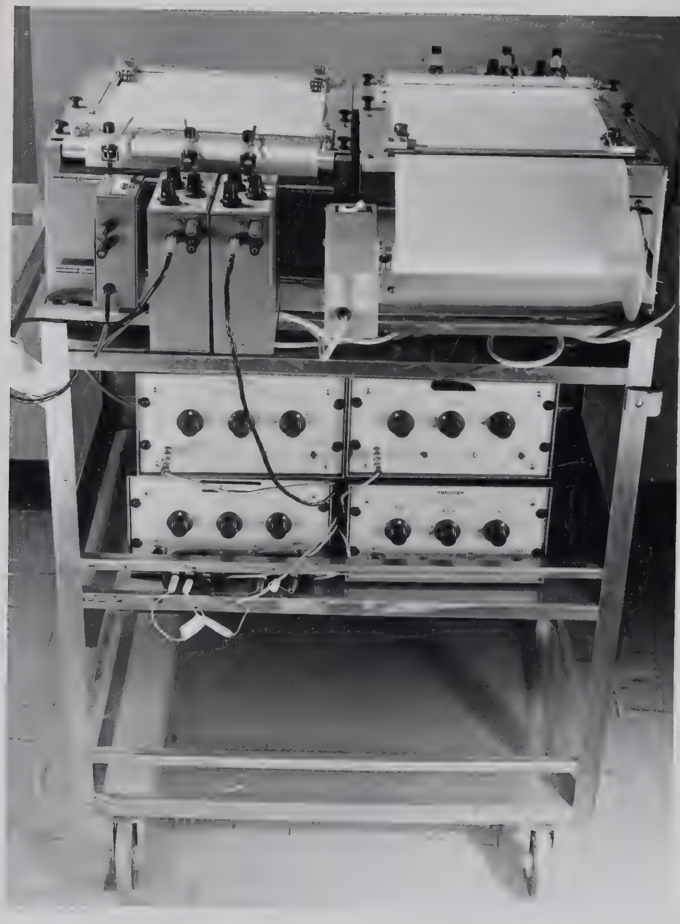

Fig. 2 - The Harvard Modular Recording system.

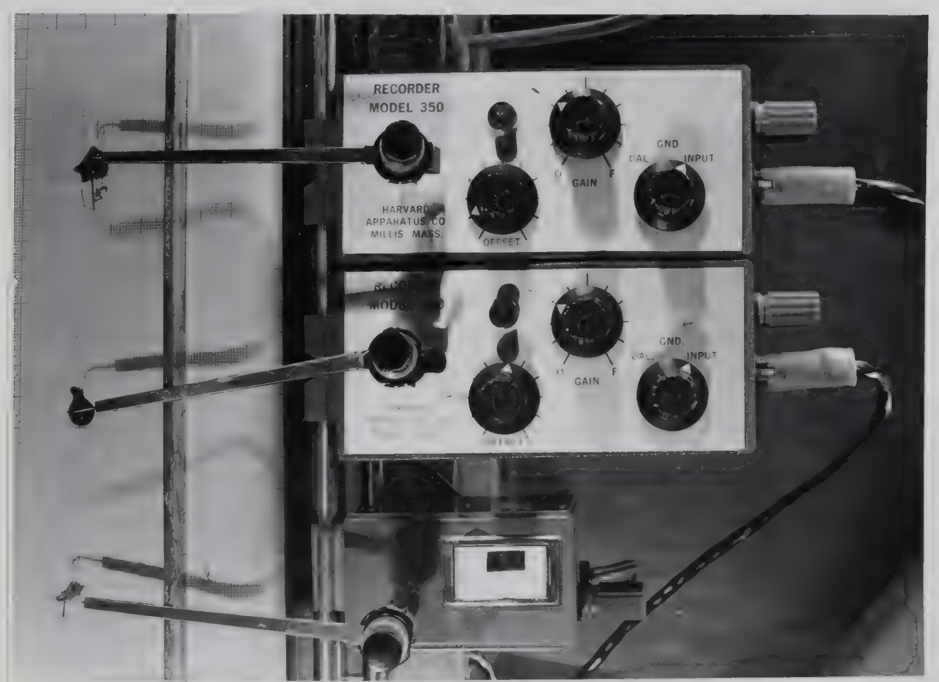

Fig. 3 - Recording modules and event marker.

Fig. 4 - Harvard bioamplifier.

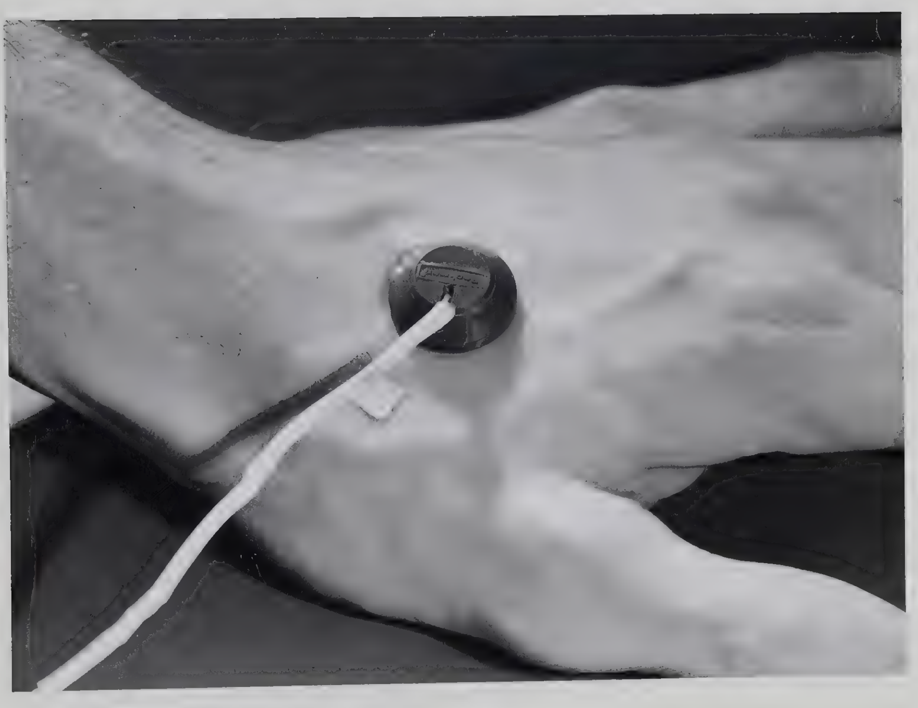

Fig. 5 - Illustration of skin electrode held in place with a self-adhesive collar.

Fig. 6 - Corrugated rubber tubing used to record changes in respiratory pattern.

Selection of Subjects

Subjects for the study had to be three or four years of age and should never have had any previous experience in a dental environment. No attempt was made to determine the nature of their previous medical experience.

The names of possible subjects were obtained from the waiting list of patients requesting treatment at the Children's Dental Clinic at the University of Alberta. The parents of these children were contacted by telephone and questioned to insure that the children had no previous dental experience. Any child who had even accompanied a parent or sibling to a dental office was excluded from the study. If the children met the requirements of the study, the purpose and procedure involved was explained to the parent. The parents were told that the child must not be informed of the purpose or true nature of the appointment. The parents were also instructed to dress children in loose clothing which would enable the placement of electrodes on the arms and legs.

The Experimental Procedure

The parent and child were met at the front door of the Medical Sciences Building by a dental nurse in ordinary clothes who escorted them to the back of the building and up a stairway to the office where the experiment was conducted. This diversion was designed to avoid contact with anyone or anything which might reveal to the child the true nature of the appointment.

The child was then seated next to the mother on the non-dental side of the partition. Attempts were made to relax the child with books, toys and pictures. When the child was settled, he was shown the electrodes and told that they were little buttons that we would stick on his arms and

legs and that they would tell us how fast he was growing. The electrodes were then placed in position in the following manner:

1. ECG electrodes were placed on the wrist of the left hand and on the right leg five inches below the knee.
2. Two EMG electrodes were placed three inches apart on the vastus medialis muscle of the left leg.
3. A common ground electrode for the ECG and EMG was placed on the left leg five inches below the knee.
4. The skin potential electrodes were placed on the tip of the thumb and tip of the little finger of the right hand.
5. The ground electrode for skin potential was placed on the lateral sufface of the thumb.

The corrugated rubber tubing to measure respiratory pattern was then placed around the chest.

When the child was satisfactorily relaxed, the technician commenced recording. The investigator then walked to the other side of the partition and returned wearing a white coat. Nothing was said to the child for one minute. The investigator then identified himself as a dentist and said that he would now examine the child's teeth.

Following a brief interval, the child was lifted to the other side of the partition and placed in the dental chair. The child was seated in the chair so that he assumed the same postural position he had when the initial recordings were taken. The child was then told that the chair would rise. Following elevation of the chair, the inspection light was turned on and adjusted to shine in the patient's mouth. The child was then shown the mirror and explorer and asked to open his mouth to allow the investigator to "look at his teeth." The examination with mirror and

explorer was carried out in the following sequence:

1. Maxillary left quadrant.

2. Maxillary right quadrant.

3. Mandibular left quadrant.

4. Mandibular right quadrant.

Following the examination the child was told that he was finished. Recordings were made for a further 30 seconds.

PART III

RESULTS AND STATISTICAL ANALYSIS

Heart Rate

The average resting heart rate was 100 beats per minute, ranging from 90 to 114 beats per minute. The rates were calculated by counting the beats in a ten-second segment and multiplying by six to convert the count to beats per minute. The average recorded changes in heart rate for specific stimuli are shown in Table I.

TABLE I

EFFECT OF DENTAL ENVIRONMENT ON HEART RATE

Stimulus	Average Change in Heart Rate
Change to white coat	+ 10 beats/min.
Statement: "I am a dentist"	+ 15 beats/min.
Elevation of the dental chair	+ 12 beats/min.
Adjustment of dental lamp	+ 10 beats/min.
Intra-oral examination	- 1 beat/min.
End of examination	- 3 beats/min.

An Analysis of Variance for a Randomized Block Experiment was applied to the data for heart rate. The effect of the dental environment was found to be significant at the 5 percent and 1 percent levels.

Electromyography

Observed increases in muscular activity were classified as slight, moderate, or pronounced. Only five of the 11 cases studied showed increased muscular activity in response to the white coat. Eight of the 11 subjects showed an increase in response to the words: "I am a dentist". All subjects exhibited moderate to pronounced increases in muscular activity in response to the dental chair, dental lamp, and intra-oral examination. Nine of the 11 subjects exhibited a decrease in muscular activity when informed that the experiment was over.

The Sign Test for non-parametric data was applied to the EMG results. The dental environment was found to have a significant effect on muscular activity at the 5 percent level.

Skin Potential

Observed increases in skin potential response were classified as slight, moderate, or pronounced. Of the 11 subjects studied, 9 exhibited an increase in skin potential in response to the various stages of the dental experimental situation. One reading was lost due to a malfunction in the recording apparatus, while the other remaining subjects showed moderate activity throughout the experiment. Following completion of the intra-oral examination, a decrease in skin potential response was exhibited in eight of the ten recorded cases.

The Sign Test for non-parametric data was applied to the skin potential data. The effect of the dental environment was found to be

significant at the five percent level.

Respiration

The variability of the collected data on respiration precludes detailed analysis, although definite changes were noted during the experimental procedures. There was a general trend toward a more rapid, shallow type of breathing. Sharp inspirations, breathholding, and gasping were also noted in response to the dental procedure.

PART IV

DISCUSSION

The rationale for using increased muscular activity as a physiological indicator of psychological tension has been well documented in the findings of Malmo and Shagass[10], Perry, Lammie, Main, and Teuscher[11], Benson and Gedye[12], Horwitz et al[13], and Yemm[14,15,16]. The increased muscular activity exhibited by all subjects in response to their initial dental experience lends support to the premise that the dental environment itself is a source of stress. The decrease in muscular activity in nine of the 11 subjects upon cessation of the experiment lends further support to this assumption.

Namin and Miller[40] list the heart rate of a normal two- to five-year-old child at a mean value of 98 beats per minute. The average recorded heart beat was 100 beats per minute during the control portion of this experiment. One can therefore assume that the subjects had achieved an acceptable level of relaxation during this period. A precise interpretation of the heart rate data is beyond the scope of this study, but several possible explanations, all of which relate to stress, are suggested in the literature. The initial acceleration in rate is in keeping with general theories of activation and arousal. Heart rate increases in the dental environment were also found by Lewis and Law[35], SRP and Kominek[34], Stricker and Howitt[37], and Corah[39]. The rapid deceleration in rate observed in the latter stages of the experimental dental procedure, particularly during the oral examination, is more difficult to interpret. One possible explanation for the decrease in rate may be that the subject was experiencing the initial stages of the common fainting attack or Vasovagal syncope. Bourne[19] mentions several facts which lend

support to this explanation. He states that fainting is especially common in the young, and that anxiety or emotional stress is a common predisposing factor. The recorded physiological changes which occurred during the dental phase of the experiment closely resemble those associated with the preliminary stages of a common fainting attack. According to Bourne, an initial increase in heart rate is followed by a decrease. The decrease is accompanied by sweating, a shallow and irregular breathing pattern, and active vasodilation, mainly in the muscles. Small convulsive movements or muscle twitching are also common features. Engel[41] believes that the basis for fainting is fear and that the accompanying physiological changes, particularly the muscle vasodilation, are part of the preparation for the fight or flight reaction. If a man responded naturally to fear by fighting or running away, Engel argues, the increased activity of the muscles and the heart would sustain the circulation. If he restrained himself and stood firm, the blood pressure would fall, with resultant fainting.

A second explanation for the observed cardiac deceleration is the concept of "autonomic specificity" proposed by Lacey[20] and Lacey et al[21]. They suggest that the orientation of the individual toward the stimulus tends to determine the response pattern of the heart rate. They hypothesized that individuals who are orientated to take in environmental input will experience cardiac deceleration. An orientation to reject the environment is associated with heart rate acceleration. Lacey's theory might explain the deceleration in heart rate during the intra-oral examination in the present project if the intra-oral examination were considered to require a greater degree of "environmental detection" by the subjects than did the other stimuli in the experiment.

A third explanation for the observed cardiac deceleration may be the effect of novelty. Stern and Word[28] suggested a relationship between novelty stress and cardiac deceleration, but this theory was not supported in the orienting response of the subjects in the present study. These subjects displayed an accelerated heart rate during the initial exposure period. The theory that cardiac deceleration is associated with novelty was supported indirectly by Lewis and Law[35], SRP and Kominek[34], Stricker and Howitt[37], and Corah[39]. Cardiac deceleration was not reported in any of their studies, all of which involved sujects with previous dental experience.

The possibility that the subject had adapted to the situation and was beginning to relax was rejected in view of the fact that the other measures of physiological response continued to indicate that the child was experiencing considerable stress.

The recorded changes in skin potential and respiration in response to the dental environment suggest that pain and discomfort are not the sole causes of patient apprehension. The data indicate that the sight of a white coat or the adjustment of the dental chair and lamp can be as stressful as an intra-oral examination.

The tape recordings of the experimental sessions and the clinical appraisal of the patient's reaction to the experiment were valueless in the interpretation of data. These records were originally designed to serve as a source of reference in the event that a wide variety of responses and/or management difficulties were encountered. None of the subjects involved in the study exhibited any resistance to any part of the experiment and, in fact, appeared to be more relaxed than

the recorded data would suggest. The tape recordings did serve as a means of checking the uniformity of the experimental procedure.

PART V

CONCLUSIONS AND RECOMMENDATIONS

Four physiological indices were used to investigate the response of children to the dental environment. Although it was beyond the scope of this experiment to project the complexities of stress phenomena to include all individuals and all dental situations, evidence has been presented to support the initial premise that the dental environment is capable of eliciting responses generally associated with stress.

The advantages of reducing anxiety are obvious to a profession which desires and expects patient cooperation. On the basis of this study, and others, it becomes apparent that our concern must go beyond the rather narrow approach of simply alleviating pain and discomfort, and should be expanded to include the total dental environment.

Physiologic measurement of autonomic responses has been shown to be a valid and practical monitor of patient response to the dental environment. Further studies, utilizing this technique, would be justified.

Some aspects of general dental practice which might be investigated are:

1. The effect of various methods of preconditioning and patient management.
2. The value and effectiveness of various premedicating agents or combinations of drugs.
3. The value and effectiveness of audioanalgesia and hypnosis.

A study involving stimulus repetition, would also provide valuable information regarding the role of "novelty" in anxiety associated

with the dental environment.

The suggested studies would enable the dental profession to examine more objectively many of the accepted dental practices which have either evolved through a process of trial and error or are based on conjecture.

APPENDIX A

COMPLETE TABLES OF RAW DATA USED IN ANALYSIS

TABLE II

CHANGES IN HEART RATE IN RESPONSE TO EXPERIMENTAL STIMULI

Subject	Normal	Change to white coat	Statement "I am a dentist"	Elevation of the dental chair	Adjustment of dental lamp	Intra-oral examination	End of examination
1	96	105	114	108	96	90	96
2	96	102	108	108	114	96	102
3	102	120	126	108	96	84	102
4	96	108	108	120	109	96	96
5	102	100	120	120	120	120	90
6	114	120	126	126	120	108	108
7	104	110	108	120	120	99	108
8	102	105	108	108	108	102	102
9	96	106	120	100	135	96	90
10	100	132	120	120	100	107	96
11	90	96	102	90	90	84	84

TABLE III

CHANGES IN SKIN POTENTIAL IN RESPONSE TO EXPERIMENTAL STIMULI

Subject	Normal	Change to white coat	Statement "I am a dentist"	Elevation of the dental chair	Adjustment of dental lamp	Intra-oral examination	End of examination
1	-	pronounced	moderate	pronounced	-	pronounced	decrease
2	-	slight	slight	moderate	moderate	moderate	decrease
3	-	pronounced	moderate	moderate	slight	pronounced	moderate
4	-	moderate	pronounced	moderate	moderate	moderate	decrease
5	moderate	moderate	moderate	moderate	moderate	moderate	moderate
6	-	-	-	-	-	-	-
7	-	Slight	Pronounced	slight	-	pronounced	decrease
8	-	-	pronounced	pronounced	pronounced	pronounced	decrease
9	-	pronounced	pronounced	-	-	moderate	decrease
10	-	slight	pronounced	moderate	moderate	moderate	decrease
11	-	pronounced	pronounced	moderate	moderate	pronounced	decrease

TABLE IV

CHANGES IN ACTIVITY OF VASTUS MEDIALUS MUSCLE IN RESPONSE TO EXPERIMENTAL STIMULI

Subject	Normal	Change to white coat	Statement "I am a dentist"	Elevation of the dental chair	Adjustment of dental lamp	Intra-oral examination	End of examination
1	-	-	Slight	pronounced	pronounced	pronounced	decrease
2	-	slight	slight	pronounced	pronounced	pronounced	decrease
3	-	slight	slight	pronounced	moderate	pronounced	decrease
4	-	slight	pronounced	pronounced	pronounced	pronounced	pronounced
5	-	-	-	moderate	moderate	pronounced	decrease
6	-	slight	slight	pronounced	pronounced	pronounced	pronounced
7	-	slight	moderate	moderate	moderate	pronounced	decrease
8	-	-	slight	pronounced	pronounced	pronounced	decrease
9	-	-	-	moderate	-	pronounced	decrease
10	-	-	-	moderate	pronounced	pronounced	decrease
11	-	-	slight	pronounced	pronounced	pronounced	decrease

TABLE V

CHANGES IN RESPIRATORY RATE IN RESPONSE TO EXPERIMENTAL STIMULI

Subject	Normal	Change to white coat	Statement "I am a dentist"	Elevation of the dental chair	Adjustment of dental lamp	Intra-oral examination	End of examination
1	21	24	18	21	24	30	21
2	24	24	24 deep breaths	27 shallow breaths	24	21	24
3	24	30	30 shallow breaths	30	30	30	-
4	-	-	-	-	-	-	-
5	30	27 deep breaths	24	27	27	25	24
6	24	30 deep breaths	35	24	24	24	24
7	24	27	27	28	26	33	24
8	18	18	18	21	18	21	18
9	24	30	33	breath-holding	gasping	24	24
10	18	24 shallow breaths	18 deep breaths	21	24	21 short, shallow breaths	15
11	27	27	breath-holding	30	breath-holding	24	24

APPENDIX B

PHOTOGRAPHS OF TRACINGS

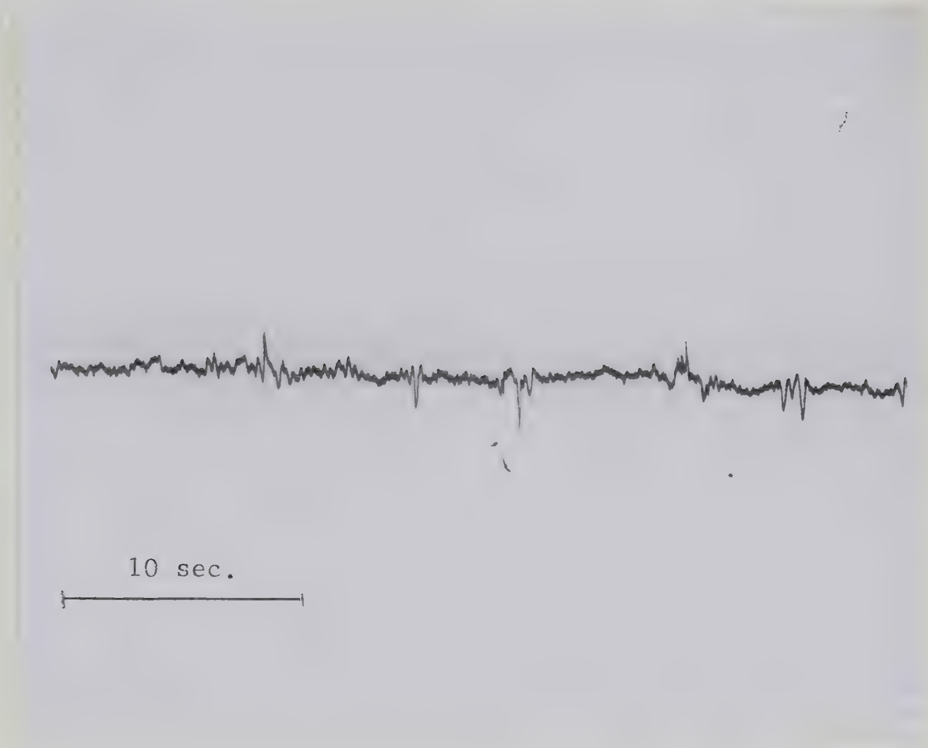

Fig. 7 - EMG of the left vastus medialus muscle, recorded when the subject was relaxed.

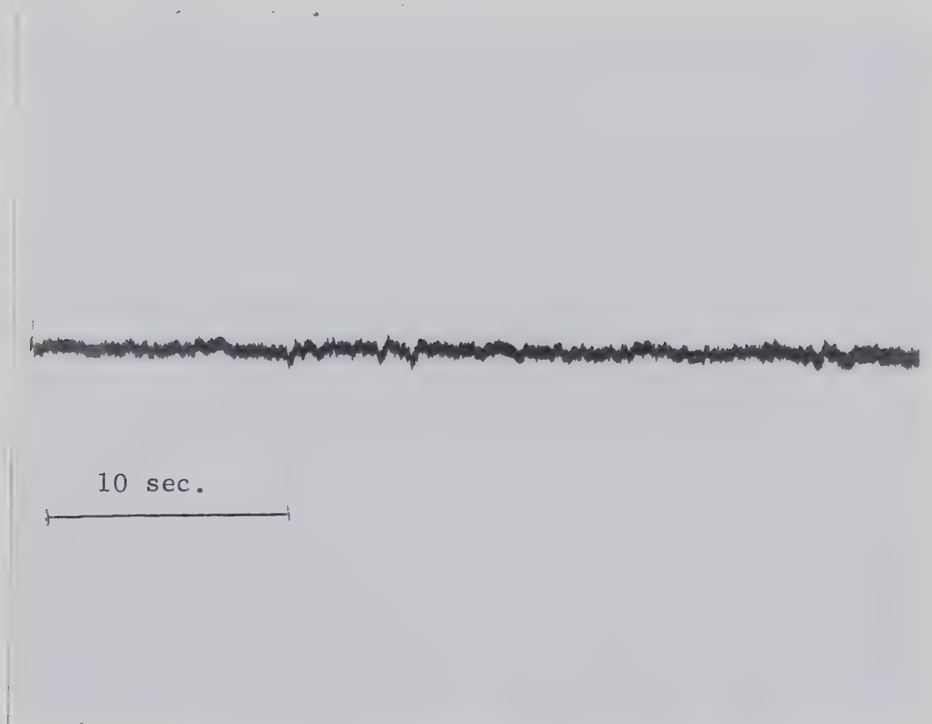

Fig. 8 - EMG of the left vastus medialus muscle, recorded after the subject was informed that he would have his teeth examined.

Fig. 9 - EMG of the left vastus medialus muscle, recorded during the intra-oral examination.

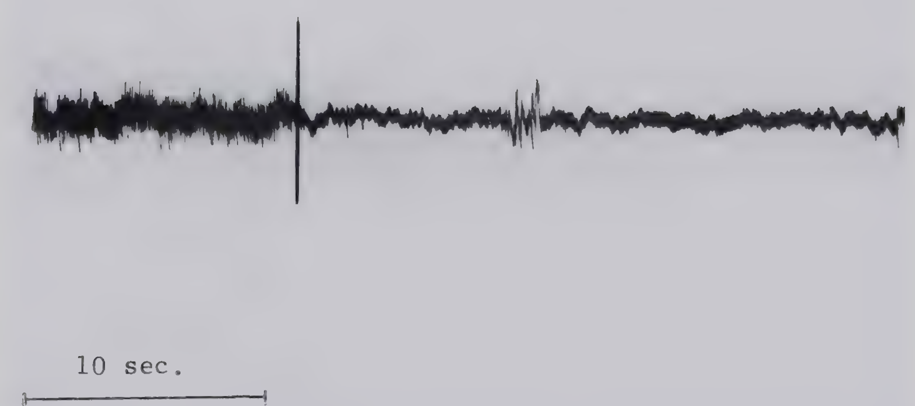

Fig. 10 - EMG of the left vastus medialus muscle, recorded at the end of the intra-oral examination. Vertical line indicates when the subject was informed the examination was completed.

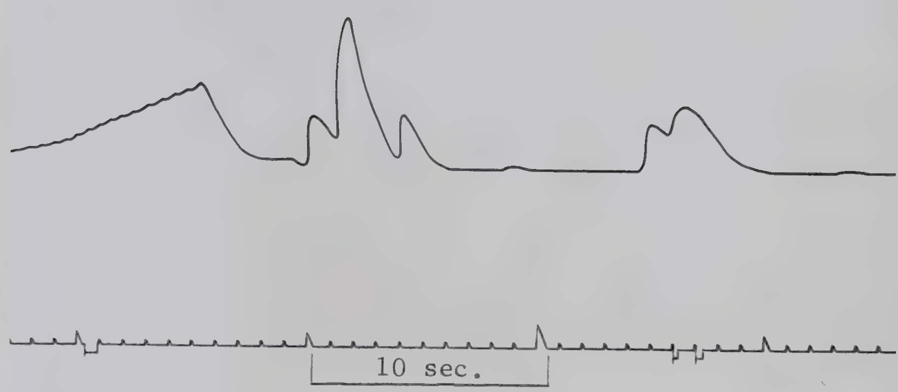

Fig. 11 - Skin potential changes recorded during the first phase of the experiment. Single downward deflection of event marker indicates entrance of investigator wearing a white coat. Double downward deflection indicates when investigator identified himself as a dentist and informed the subject that his teeth would be examined.

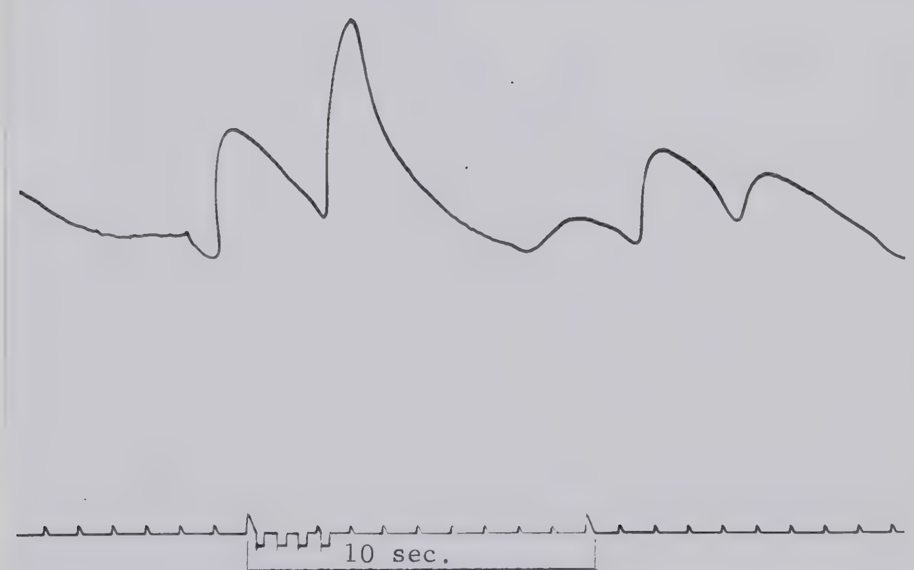

Fig. 12 - Skin potential changes recorded during elevation of the dental chair. Downward deflection of event marker indicates when the chair started to rise.

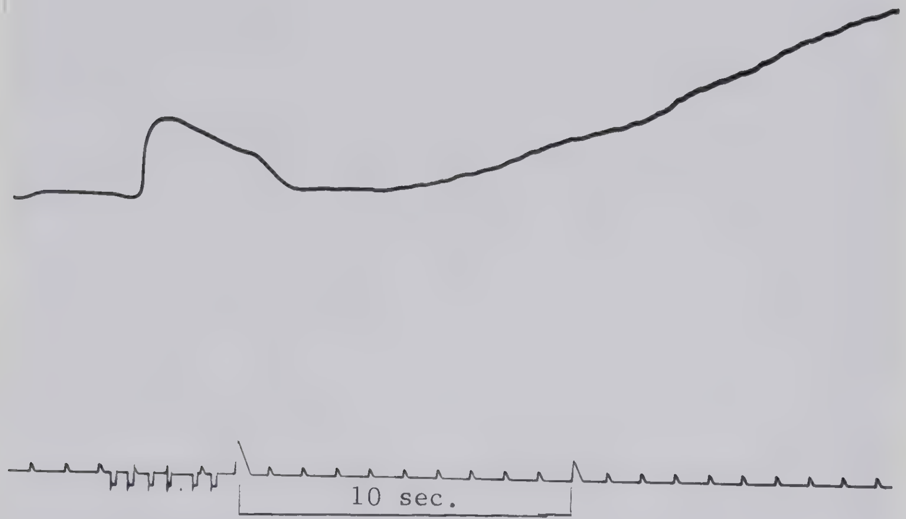

Fig. 13 - Skin potential changes recorded during the intra-oral examination. Downward deflections of the event marker indicate the beginning of the examination.

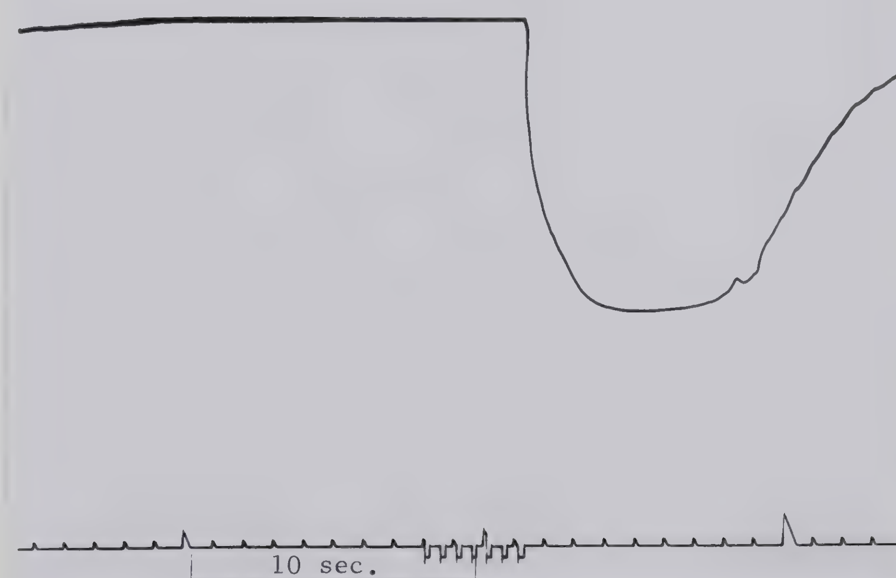

Fig. 14 - Skin potential changes recorded at the end of the experiment. Downward deflections of the event marker indicate when subject was informed that the examination was completed.

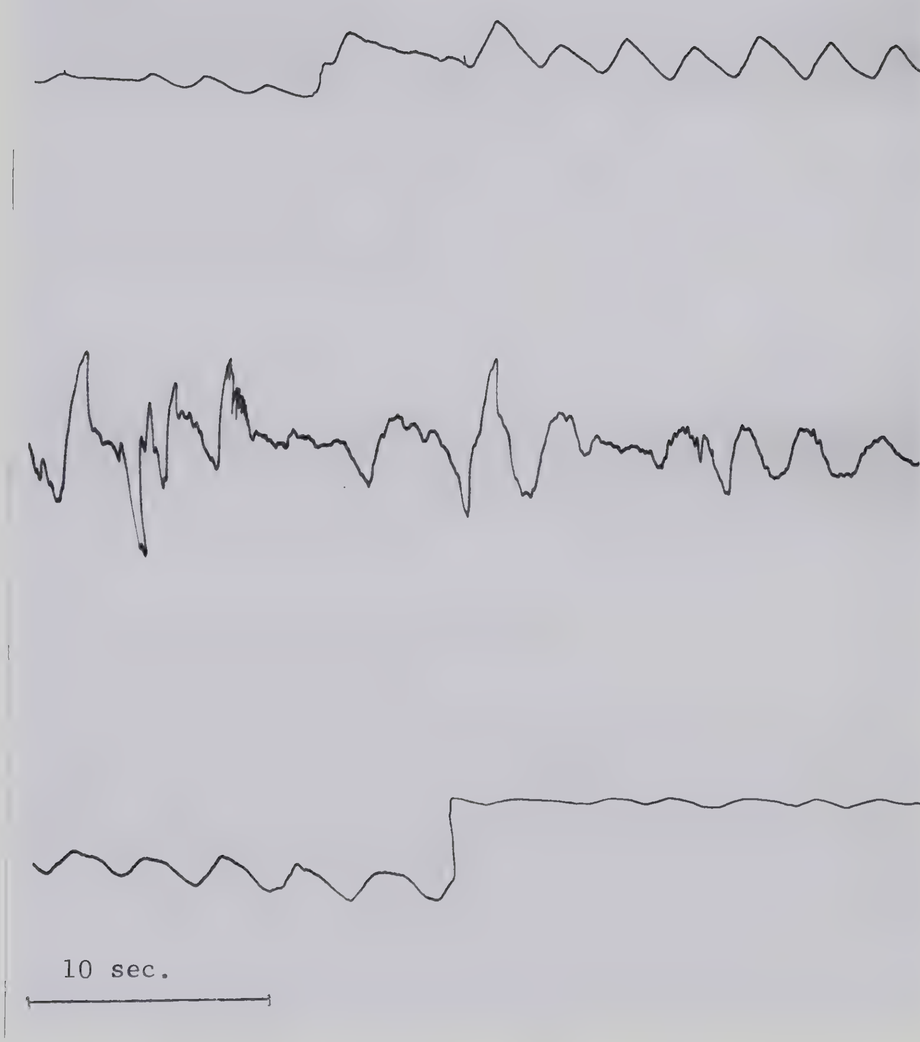

Fig. 15 - Three tracings of respiratory movement illustrating variability of response pattern.

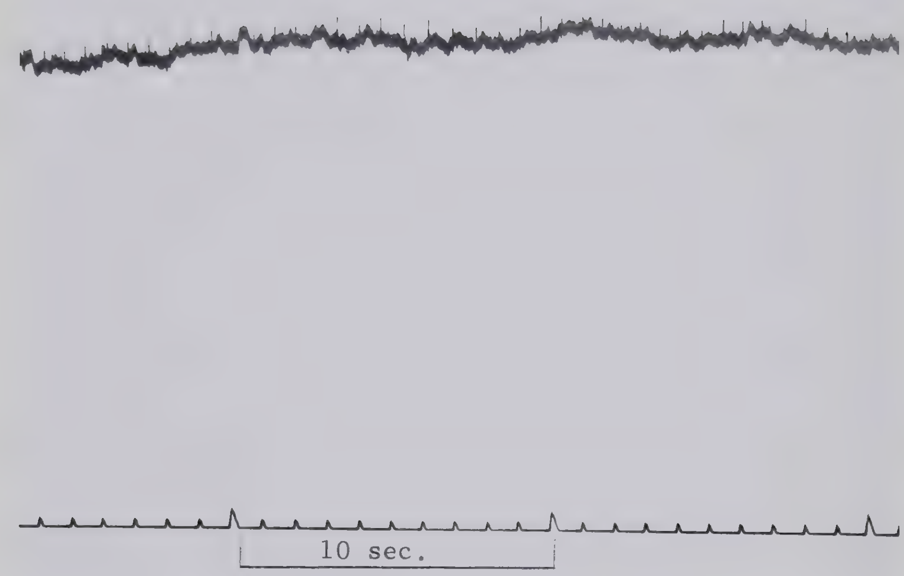

Fig. 16 - Example of ECG tracing recorded when the subject was relaxed. Rate, in beats per minute, was calculated by counting the peaks in a 10 second period and multiplying by six. The rate for the ten-second period was calculated by taking an average of the rates recorded throughout the specific stimulus period.

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